NOTICE

U.S. Department of Transportation
Federal Aviation Administration

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Cancellation
Date: 5/11/01

SUBJ: GUIDELINES FOR THE OVERSIGHT OF SOFTWARE CHANGE IMPACT ANALYSES USED TO CLASSIFY SOFTWARE CHANGES AS MAJOR OR MINOR

1. PURPOSE. This notice provides guidelines to Aircraft Certification Office (ACO) engineers and Designated Engineering Representatives (DER) for overseeing an applicant's change impact analysis process. These guidelines are applicable to software changes related to type certificate (TC) approvals, amended type certificate (ATC) approvals, supplemental type certificate (STC) approvals, Parts Manufacturer Approvals (PMA), and Technical Standard Order (TSO) authorizations.

2. DISTRIBUTION. This notice is distributed to the branch level in Washington Headquarters Aircraft Certification Service, section level in all Aircraft Certification Directorates, all National Resource Specialists (NRS), all Aircraft Certification Offices (ACO), all Manufacturing Inspection Offices (MIO), all Manufacturing Inspection District or Satellite Offices (MIDO/MISO), and all Flight Standards District Offices (FSDO). Additional limited distribution should be made to the Air Carrier District Offices, the Aeronautical Quality Assurance Field Offices, and the FAA Academy.

3. RELATED PUBLICATIONS.

a. Advisory Circular (AC) 20-115B, "RTCA, Inc. Document RTCA/DO-178B," dated January 11, 1993.

b. RTCA, Incorporated, document RTCA/DO-178B, "Software Considerations in Airborne Systems and Equipment Certification," dated December 1, 1992.

c. Title 14 Code of Federal Regulations (14 CFR), Part 21, "Certification Procedures for Products and Parts."

4. BACKGROUND.

a. On January 11, 1993, the FAA issued AC 20-115B which recognizes DO-178B as a means to secure FAA approval of digital computer software. DO-178B, Section 12.1.1, identifies analysis activities to be performed for proposed software changes. DO-178B also implies that re-verification should be accomplished on all software changes and areas affected by those changes.

b. The purpose of this notice is to provide a standardized process to determine the impact of a software change on a system, in order to assure that safety is not adversely impacted. The notice

focuses on the change impact analysis to determine the extent of certification authority involvement in the review of the changes and to determine the significance of the change in the overall project.

c. The change impact analysis may be used by an applicant to provide justification for the classification of a change as it relates to 14 CFR Parts 21.93 and 21.611. This notice does not contain examples of minor or major changes, but it does offer guidelines for analyzing the impact of software changes. Changes analyzed as minor (using the guidelines of this notice) for products previously approved under the TSO authorization process should be tested and verified by the applicant, but require no further oversight by the ACO engineer (reference 14 CFR, part 21). Likewise, changes analyzed as minor (using the guidelines of this notice) for products previously approved under the TC, STC, or ATC process should be tested and verified by the applicant and may be implemented for the software portions without further oversight by the ACO engineer or DER, if authorized, in accordance with 14 CFR, part 21. However, the substantiation and description of the change(s) should still be submitted to the ACO in accordance with the delegation agreement.

5. DISCUSSION.

a. The applicant should identify the software changes to be incorporated in the product and perform a change impact analysis. The change impact analysis should follow a defined process to accomplish its purpose of determining the potential impact of the change on continued operational safety of the aircraft on which the product is installed. In the case of TSO authorized equipment, the analysis should identify the intended target aircraft environment which forms the basis for the analysis. This analysis also provides a basis for determining the extent of certification authority involvement. The following items should be addressed by the change impact analysis, as applicable:

(1) **Traceability analysis** to identify areas which could be affected by the software change. This includes the analysis of affected requirements, design, architecture, code, testing and analyses, as described below:

(a) *Requirements and design analysis* to identify software requirements, software architecture, and safety-related software requirements impacted by the change. Additionally, the analysis identifies any additional features and/or functions being implemented in the system, assures that added functions are appropriately verified, and assures that the added functions do not adversely impact existing functions.

(b) *Code analysis* to identify the software components and interfaces impacted by the change.

(c) *Test procedures and cases analysis* to identify specific test procedures and cases that will need to be re-executed to verify the changes, to identify and develop new or modified test procedures and cases (for added functionality or previously deficient testing), and to assure that there are no adverse effects as a result of the changes. The absence of adverse effects may be verified by conducting regression testing at the appropriate hierarchical levels (e.g., aircraft

flight tests, aircraft ground tests, laboratory system integration tests, simulator tests, bench tests, hardware/software integration tests, software integration tests, module tests), as appropriate for the software level(s) of the changed software.

(2) **Memory margin analysis** to assure that memory allocation requirements and acceptable margins are maintained.

(3) **Timing margin analysis** to assure that the timing requirements, central processing unit (CPU) task scheduling requirements, system resource contention characteristics, interface timing requirements, and acceptable timing margins are maintained.

(4) **Data flow analysis** to identify changes to data flow and coupling between components and assure that there are no adverse impacts.

(5) **Control flow analysis** to identify changes to the control flow and coupling of components and to assure that there are no adverse impacts.

(6) **Input/output analysis** to assure that the change(s) have not adversely impacted the input and output (including bus loading, memory access, and hardware input and output device interfaces) requirements of the product.

(7) **Development environment and process analyses** to identify any change(s) which may adversely impact the software product (e.g., compiler options or versions and optimization change; linker, assembler, and loader instructions or options change; or software tool change).

(8) **Operational characteristics analysis**, such as evaluation of changes to gains, filters, limits, data validation, interrupt and exception handling, and fault mitigation to assure that there are no adverse affects.

(9) **Certification maintenance requirements (CMR) analysis** to determine whether new or changed CMRs are necessitated by the software change.

(10) **Partitioning analysis** to assure that the changes do not impact any protective mechanisms incorporated in the design.

NOTE: The above list is not all inclusive and is dependent on the product for which the modification is being made.

b. The change impact analysis should determine whether the change could adversely affect safe operation of the system or product. The following are examples of areas that could have an adverse impact on safety or operation:

(1) **Safety-related information is changed**. For example:

(a) Previous hazards, as identified by the system safety assessment, are changed.

(b) Failure condition categories, as identified by the system safety assessment, are changed.

(c) Software levels are changed, particularly if the new software level is higher than the previous level.

(d) Safety-related requirements, as identified by the system safety assessment, are changed.

(e) Safety margins are reduced.

(2) **Operational or procedural characteristics of the aircraft are changed in a manner that could adversely affect flight safety as a result of the software change.** For example:

(a) Aircraft operational or airworthiness characteristics are changed.

(b) Flight crew procedures are changed.

(c) Pilot workload is increased.

(d) Situational awareness, warnings, and alerts are changed.

(e) Displayed information to make flight decisions is changed.

(f) Assembly and installation requirements are changed.

(g) Changes that affect equipment interchangeability and/or interoperability with other equipment.

(h) CMR's are changed or added.

(3) **New functions or features are added to the existing system functions that could adversely impact flight safety.**

(4) **Processors, interfaces, and other hardware components or the environment are changed in such a way that safety could be adversely affected**. Reference DO-178B, Section 12.1.3.

(5) **Software life cycle data (e.g., requirements, code, architecture) is significantly changed in such a way that it could adversely affect safety**. For example:

(a) Software requirements, design, architecture, and code components (especially those affecting safety-related functions, partitioning, redundancy or safety monitors) are changed.

(b) Code (source, object, and executable object) components that perform a safety-related function or a component which provides an input to a component which performs a safety-related function are changed. (For purposes of this notice, a safety-related function is one which could potentially induce or allow a major, hazardous, or catastrophic failure condition to go undetected).

(c) Characteristics of the development environment impacting the executable object code are changed.

(d) Memory allocation requirements are changed in such a way that memory margins are adversely impacted (e.g., less than 5 percent margin remaining).

(e) Timing requirements are changed in such a way that timing margins are adversely impacted (e.g., margins are unpredictable or less than 10 percent margin remains).

(f) Input/output requirements (e.g., bus loading) are changed in such a way that input or output performance is adversely impacted (e.g., less than 5 percent margin remains).

(g) Data and control coupling characteristics are adversely impacted (e.g., to the extent that more than 50 percent of the coverage analysis must be redone).

(h) Interface characteristics are changed.

c. Additionally, the following items should be identified in the change impact analysis:

(1) **Updates** that will be needed to assure that the software change(s) is incorporated in the appropriate software life cycle data, including requirements, design, architecture, source and object code, and traceability.

(2) **Verification activities** that will be needed to verify the changes and to verify that there are no adverse effects on the system. The change impact analysis should address how changes which could adversely affect safe operation of the system or aircraft will be verified, such that the changed and unchanged software will continue to satisfy their requirements for safe operation. These verification activities may include reviews, analyses, regression testing, requirements-based testing, flight testing, etc., including re-evaluation of existing analyses, re-execution of existing tests, and new test procedures and cases (for added functionality or previously deficient testing).

6. PROCEDURES. Each project involving software changes has different needs. This section outlines procedures for the ACO engineer or DER, if authorized, to consider with the applicant when addressing software changes.

a. The applicant may define and follow a procedure for classifying software changes as major or minor and should seek ACO review, feedback, and approval for that procedure. As a minimum, any such procedure should address the following before being implemented:

(1) The applicant's process for using the change impact analysis (as addressed in section 5 of this notice) to justify a minor or major change classification and the criteria used by the applicant to make the change classification.

> NOTE 1: The extensiveness and formality of the change impact analysis will vary by complexity, criticality, and extensiveness of the change. The change impact analysis may be in-depth for complex, highly critical systems but may be briefer and less rigorous for less complex or less safety critical systems or less extensive changes.
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> NOTE 2: The applicant's documentation should address the categorization of the change as minor or major, per the appropriate regulations, (e.g., Part 21.93 and/or Part 21.611) in order to obtain FAA agreement on the change classification.

(2) The applicant's process to review and approve the change classification (e.g., DER review and approval).

(3) The process to be followed for a minor change determination (reference section 6c of this notice).

(4) The process to be followed for a major change determination (reference section 6d of this notice).

(5) The process for informing the FAA of all proposed software changes and their proposed classifications.

(6) The process for obtaining FAA concurrence with the proposed classifications.

> NOTE: Once ACO approval of the software change classification procedure has been granted, the applicant should follow the procedure for all proposed software changes. Deviations from the approved procedure should obtain FAA concurrence.

b. If the applicant does not have an FAA approved software change classification procedure, the applicant should inform the FAA and/or DER, if applicable, that a software change is being planned. In these cases, the applicant should perform the following activities:

(1) Perform a change impact analysis, using the guidelines in section 5 of this notice.

(2) Propose a major or minor classification for the change (based on the change impact analysis and safety implications as stated in section 5 of this notice) and seek FAA feedback and concurrence on the classification.

(3) Support any proposed minor classification with rationale about the absence of safety impact and/or the limited scope of the change, and the proposed method of verifying the change. After the FAA has agreed to the applicant's data and rationale, the applicant may proceed without further FAA oversight for minor changes (reference section 6c of this notice).

(4) Submit the appropriate documentation to the FAA for major changes (reference section 6d of this notice).

c. For minor changes, the ACO oversight of the development process should involve approval and periodic review of the applicant's change impact analysis process and associated criteria for making a major/minor determination with respect to the relevant regulations. Once the change strategy and the change itself have been performed, the strategy should be documented in the Software Accomplishment Summary (SAS). New, modified, and re-used software life cycle data should also be identified in the Software Configuration Index (SCI). For minor changes, submittals of the SAS and SCI to the ACO should be per agreement with the ACO.

> NOTE 1: When applicable, DER's should be involved in the change classification procedure and oversight of the company's adherence to that procedure.
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> NOTE 2: Equipment containing changes that are classified by the manufacturer as minor but not yet concurred with by the ACO or DER, when authorized, should be withheld from installation on flight aircraft until the ACO concurs with the classification.

d. For major changes, the ACO engineer and/or DER, if authorized, should review the applicant's Plan for Software Aspects of Certification or other summary of change impact analysis data and the applicant's proposed strategy for addressing the change issues. Once the change strategy and the change itself have been carried out, the ACO engineer and/or DER, if authorized, should assure that the strategy is documented and submitted in the SAS. New, modified, and re-used software life cycle data should also be identified in the SCI and submitted to the ACO engineer and/or DER, if authorized to approve major changes.

> NOTE: In many cases, a change process may already be in place to address major, minor, significant, insignificant, small, simple, etc. changes. The applicant's change impact analysis activities (in accordance with this notice) should fit within their already existing framework in order to avoid unnecessary or inappropriate activities.

7. CONCLUSION. The information and procedures described in this notice promote clarification and consistent application of AC 20-115B for the approval of changes to the software or its environment in the airborne system and equipment. This notice does not replace or supersede AC 20-115B or DO-178B.

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